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RELIABILITY & MAINTAINABILITY:

DoD's Testing Factors

Why DoD Emphasizes RELIABILITY & MAINTAINABILITY In Testing

Field reliability, maintainability and support costs are receiving major new emphasis in the Defense System Acquisition Review Council (DSARC) decision process. DSARC reviews are requiring that test results, evaluating these parameters, be reported at the decision points. To make this a viable process, there are a number of pragmatic and conceptual issues, such as definitions, structuring of program schedule and test plans, etc. which must be considered. We will discuss these issues from the different perspectives resulting from our experience and present positions.

Since it is important to understand clearly the reasons for the DSARC let us briefly take a look at the background consideration which led to the recognition that reliability, maintainability and support costs must receive additional review and emphasis.

I'm sure that you are aware, both from personnel and business experience, of the loss in purchasing power of the dollar. Since 1968 the Department of Defense (DoD) procurement buying power has gone from $44 billion in outlays (in constant 1976 dollars) to approximately $17 billion in 1975. Simultaneously, we have experienced higher weapon system production unit costs due to inflation and increases in performance requirements. This has resulted in a downward trend in U.S. baseline forces.

Force Contrast

As a sample of what has happened to U.S. forces during the 1968 to 1975 time period, we saw the number of U.S. tactical aircraft reduced from 5,000 to 4,000. In contrast, during the same time period, the number of Soviet tactical aircraft increased from 4,000 to more than 5,000, a reversal of the U.S. situation. Also during this time period the number of U.S. major surface combatants went from more than 300 to less than 200, while the number of Soviet major surface combatants increased to more than 200.

Concurrently with the loss of weapon procurement purchasing power, we also saw the growth of unit production costs of systems — thus the design to cost initiatives — and the growth of operating and support costs. For example, the operations and maintenance budget line item has increased from 23 per cent to more than 30 per cent of the total DoD budget. Our other major operation and support (O&S) cost budget line item — manpower costs — remained essentially constant in spite of a reduction of one million men. The reason is because the cost of the individual soldier has doubled since 1968. In that same period of time the procurement line item decreased from 32 per cent to 22 per cent (the procurement line was as low as 20 per cent in 1975). Thus it is obvious the O&S growth came at the expense of reduction of procurement.

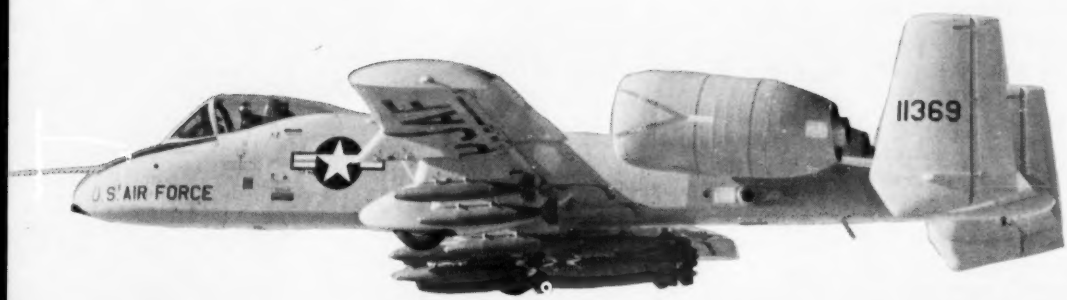
JACQUES S. GANSLER
Deputy Assistant Secretary of Defense
(Materiel Acquisition)

Though we have increased our support cost expenditures, our material readiness has decreased. In the past two years the percentage of Navy aircraft grounded awaiting spare parts increased from approximately 15 per cent to 22 per cent. In the past five-year period the backlog of overdue ships' overhauls increased from 2 per cent to 14 per cent. There is also concern about the material available to support many Army units, particularly Reserve units.

Secretary of Defense Donald Rumsfeld, in his Annual Defense Department Report for FY 77 and his FY 77 Budget Perspective, stated that U.S. military capability can today be described as sufficient, that is, we have a "rough equivalence" to the Soviet Union. He also warned that our posture must be strengthened, because we have potential vulnerabilities such as aging of forces and reduced readiness.

Congress has recognized DoD's need and there have been additional funds added to modernize and improve our forces. But this approach alone cannot solve the problem. Our

Production funding for the A-10 aircraft was held back by the Department of Defense until the reliability and maintainability testing was satisfactorily completed.



long term strategy must recognize that we are working with limited funding resources. What we must do is try to reverse the increasing O&S cost trend. We have to try to put ourselves in the position we were in 15 years ago when procurement constituted a larger percentage of the DoD budget than operations.

The need to control costs, both O&S and production, led to the introduction of a number of DoD initiatives. Initially, approaches such as design to cost, emphasis on commonality, use of commercial hardware, tailoring of specification and standards were aimed primarily at reducing procurement costs. Then DoD directive 5000.28 "Design to Cost," was issued in May 1975. It extended the design to cost concept of management and contract to life cycle costs.

Directive Guidance

The guidance in the 5000.28 directive provided that "during design and development, costs (i.e., life cycle costs) requirements and the achievement of cost goals will be evaluated with the same vigor as technical requirements and the achievements of performance goals." And, that specific management objective during design development is the control of future operating and support costs. The major operating and support costs function would "have goals established in the form of measurable numbers (e.g., number of O&S personnel, reliability and maintainability factors, etc.) which can be monitored during test and evaluation as well as operation."

The concern for the need to control and reduce O&S costs was further reinforced by a February 1976 memo by Deputy Secretary of Defense William Clements to the Services. The Services were requested to work toward a reduction of the overall out-year budget allocated to O&S costs. These actions were to be accomplished through a process which involved establishing individual O&S cost goals for new systems, comparison of new system O&S cost goals to existing systems, making program decisions considering O&S cost impact, requiring system trade-offs of logistic concepts, manpower, reliability and maintainability, and yearly Service assessment of progress.

With this as background, let us examine what the DSARC actions have been as a result of this new policy. The most important indicator of whether the DSARC principals and Services' management are spending their energies on reliability problems is in terms of specific DSARC decisions based on achieving goals. A review of recent

decisions shows clear evidence of the seriousness with which reliability has come to be viewed.

In the AIM-9L missile program, production was limited until system reliability had been demonstrated. The Condor missile production program was to be held to low production rates until a new program plan which emphasized reliability and quality was proposed. The Captor program has been held at minimum production levels, reduced until the system fully demonstrates its operational reliability. And the release of production funding for the A-10 was held back until the reliability and maintainability testing was satisfactorily completed.

It is interesting to observe that these decisions have all come in the last two years, and were based on test results. Previously less attention was paid to the reliability, maintainability and support cost areas. The test and evaluation (T&E) process has become the force for establishing reliability and maintainability performance milestones together with the resources to achieve their performance. But test and evaluation should not be viewed as simply part of a roadblock process. The prime motivation in performing tests is to identify problem areas, so that corrective action can be undertaken.

The contract for the F-16 (left) has a target logistic cost requirement built into it. The Navy's Condor missile was held to low production rates until a new program plan which emphasized reliability and quality was proposed.

Observations

Certain observations should be made in considering reliability and maintainability as factors in testing. First, one must recognize that reliability and maintainability are not like other performance parameters. While we expect to measure other performance parameters, such as speed or accuracy, against their goal values, reliability and maintainability parameters are generally measured against intermediate values. The probabilistic nature of the reliability and maintainability parameters and the sensitivity of their measurement to the environment make high confidence reliability and maintainability measurement extremely expensive and time consuming. For example, in the aerospace area (e.g., space and strategic missiles), where reliability performance is critical, 40 per cent of the program life cycle cost is for testing.

Though we are trying to strive for better correlation between field performance and test results, we must balance the costs of testing against the risks. Test costs should not be out-of-line with the costs to develop or procure the system.

Second, we must start our reliability and maintainability testing early in the design stage. We must capture design proofing and laboratory data. This will

allow us to build a history which we can correlate with later field demonstrations and field operational performance.

Third, I think it is essential that the good start in setting-up independent test groups be maintained. Because judgments about reliability and maintainability performance, particularly future performance, may involve subjective evaluation, the test groups must maintain their independence for the T&E process to remain credible.

With these observations in mind, let me suggest some factors which should be considered to strengthen the testing and evaluation of reliability and maintainability.

One of the initial problems encountered in structuring reliability and maintainability goals and test thresholds is the lack of a common understanding of the reliability and maintainability terms. Since a primary objective is to predict with confidence from our T&E results how the system will perform in the field, we would expect to see reliability and maintainability expressed in field terms.

Until recently this has not been the case. In one program when the reliability goals were redefined, with a considerable effort, into field terms, the goal in field terms was approximately 11 per cent of the specified program goal. If each new program has its own unique definitions, we would not be able to compare the new system against the system it replaces. Programs would not be designed or tested with the prime objective of solving field problems. We are working with the Director of Defense Research and Engineering (DDR&E) to define field reliability and maintainability terms. Until the terms are defined and agreed to by the Services, each new program should define reliability

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and maintainability goals and test thresholds to reflect field performance.

Another major problem we encounter in programs is the lack of realistic reliability and maintainability goals and test thresholds. When the F-18 program was initially submitted for review, a higher reliability goal was proposed. The program now has a lower but more realistic reliability goal and is more precisely defined in field terms. Even now this goal is twice what would be expected if no special action were to be taken. Test and evaluation is an important part of this process because the weapon system will be evaluated during the development phase on the progress to achieving this goal. In the F-18 example, the goal was used as the starting point to establish the test thresholds. By establishing a reasonable goal and test thresholds the program has no excuse for not trying to achieve this goal.

Specific Terms

An area which needs further thought involves the selection of the specific reliability and maintainability terms to be tested. What has to be measured should be related to the end results. For example, in the Utility Tactical Transport Aircraft System (UTTAS) program, one of the justifications for the program was that its operating and support cost was projected to be lower than that of the UH-1, the helicopter it is replacing. The helicopter system MTBF (mean time between failure) was chosen as the reliability parameter which was most indicative of the helicopter operating and support costs. However the MTBF term included in its aggregate such small items as light bulbs, and therefore did not give a true projection of the helicopter costs. Recently it has been suggested that the dynamic components MTBR (mean time between removal) was a more meaningful reliability term, because this term reflected the frequency of maintenance on the items with high O&S costs. Unfortunately it takes more time to test the MTBR term. Though this particular problem has not been resolved, the program manager's approach to choosing the most meaningful reliability and maintainability terms is very encouraging.

The need to demonstrate reliability and maintainability has encouraged program managers to involve contractors more directly. The structure of the F-18 contract is a good example of this impact. The contractor is given a substantial award fee based on successful demonstration of reliability and maintainability parameters prior to key DSARC decision points. In addition there is an award fee associated with the contract's life cycle cost management efforts. Some factors that the Navy will use to award the life cycle cost fee include the ability to define an acceptable reliability warranty program, effective control of subcontractor life cycle cost parameters, engineering effectiveness in resolving life cycle cost problems and life cycle reduction and trade-offs achieved during development.

Even more encouraging is the involvement of our contractors in validating the supportability of Defense's system. One such approach that appears to hold promise is the target logistic cost requirement used in the F-16 contract. The contract requires a measurement of equipment performance in the field which is input into a cost model that projects life cycle cost. The measured cost is then compared against a life cycle cost target. Corrective action will be taken in the logistic area that most adversely affects the life cycle cost if the target is not met. Also a similar approach will be used in the A-10 program where aircraft support costs will be projected based on aircraft performance in the operational squadron. In both these approaches the contractors have monetary incentives to meet specified goals.

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Production of the AIM-9L missile, such as the ones on this YF-17 aircraft, was limited until a program of system reliability was demonstrated.

Difficult Problem

Also, DoD needs to develop approaches to test system supportability as well as imposing this requirement on the contractor. This is a difficult problem. To test system supportability, we need to have logistic elements such as training and test equipment in hand. But these logistic elements are not generally bought until after the production decision. One approach to testing supportability is for the Service to evaluate the system after it deploys. A second approach would be to intensify our evaluation of system maintainability which is a key support "driver". Unfortunately the methodology for prediction, design and testing of maintainability is much less developed than for reliability. Maintainability measures would allow assessment of maintenance manpower and some major logistic components. The combination of the maintainability and reliability measurements would allow DoD to assess system O&S costs and readiness. Both the test and design communities face major challenges in the area of maintainability evaluation.

Software has been a high-cost area to DoD and a contributor to poor system reliability. The Defense Science Board's task force on test and evaluation has recently reported that no standard procedure is in existence for the orderly testing of software items. Defense is developing a test concept based on validation and verification of the software. This concept involves independent test and evaluation of the system in an incremental fashion and providing feedback into the design where there is still time to correct the fault.

These principles apply equally as well to modification of equipments. The "mod" areas are becoming increasingly important as we try to extend the life and improve the capability of our existing capability.

Several areas have been enumerated which could be strengthened to improve the test evaluation of reliability and maintainability. But, in conclusion, Defense has a credible T&E process which has emphasized testing of reliability and maintainability. This has helped to readjust and equalize the balance between performance, reliability and maintainability and support costs. A strong test and evaluation process is turning DoD policy procurements into meaningful actions.

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